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# Terminal Moult of the Male Snow Crab in the Sea of Japan[1]

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(Received January 16, 1991)

The terminal molt of the male snow crab *Chionoecetes opilio* was studied using 1,638 male crabs with a carapace width larger than 60 mm caught by Danish seine, trap and beam trawl in the Japan Sea from August 1989 to October 1990. For estimation of the molting stages of male crabs, the second maxilla was taken, and the carapace width and chela height of each individual was measured.

In examination of the relationship between carapace width and chela height, male crabs were divided into two groups, those with a relatively large chela height (large-clawed crabs), and those with a relatively small chela height (small-clawed crabs). In the small-clawed crabs, intermolt, premolt and postmolt stages were mainly observed from February to May, from June to September, and from September to October, respectively. On the other hand, almost all the large-clawed crabs were at the intermolt stage throughout the year, and the postmolt stage was observed from September to October. These results indicate that small-clawed crabs continue to molt once a year, whereas large-clawed crabs have already undergone the terminal molt.

Researchers have for some time now been studying the growth of snow crabs (*Chionoecetes opilio*) in the Sea of Japan. It has been thought that, whereas the female undergoes terminal moult upon maturing and grows no larger, the male continues to grow and moult

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until it dies.[1-3] However, a recent study[4] in Canada's Gulf of St. Lawrence (an appendage of the North Atlantic) has indicated that the male crab undergoes terminal moult like the female. According to this report, the claws of specimens that have undergone terminal moult are relatively large compared to the width of their carapace, while the claws of those that have not undergone terminal moult are relatively small.

Past research conducted in the Sea of Japan also reported a relationship between carapace width and relative claw growth among male crabs.[5] The research showed that it is possible to divide crabs into two groups on the basis of different ratios between these two variables and that crabs with high ratios were numerous in the group with wide carapaces. The authors marked and released a number of male crabs and found that many of them did not moult during the one to three years that preceded recapture.[6] These study results suggest that male crabs in the Sea of Japan may undergo terminal moult like those in the North Atlantic.

Given the marked deterioration of our stocks and the resulting need to examine resource management, there is an urgent need to answer these and other questions concerning the basic biological nature of moulting and growth among male crabs. The authors examined 1,638 male crabs caught in the Sea of Japan, looking at the relationship between the carapace-to-claw growth ratio and terminal moulting, and report that male snow crabs in the Sea of Japan likely undergo terminal moult as well.

## Materials and Method

This study involved a total of 1,638 male crabs caught at depths of between 230 and 350 metres off Kyoto Urban Prefecture between August 1989 and October 1990 using crab traps, Danish seine nets and beam trawl nets (Table 1). We measured the maximum carapace width and chela height of the captured male crabs with slide callipers to the nearest millimetre (as a rule measuring the right claw - Figure 1). We used the same measuring method as that employed by Conan and Comeau.[4] We excluded from our analysis crabs whose right claw was missing or was clearly abnormal due to regeneration.

To determine what moulting stage each specimen was in, we collected the second maxilla from all the specimens (Figure 2). Except for those cases when we examined the second maxilla immediately after collection, we preserved them in a solution of sea water and formalin (3 per cent). We gauged what moulting stage the crab was in by using an optical microscope to determine the degree of formation or separation of the new and old epidermis and seta at the margin of the second maxilla's basipodite.

## Results and Discussion

**Carapace-width-to-chela-height growth ratio** Figure 3 shows the logarithmically converted relationship between carapace width and chela height for the male crabs captured. Figure 3 shows that all the crabs with carapace widths of 70 millimetres and less

belonged to the group with the lower chela-height-to-carapace-width ratios (the small-clawed crabs), while of all those with carapace widths of 120 millimetres and up belonged to the group with higher ratios (the large-clawed crabs). Members of both groups were found with carapace widths of between 70 and 120 millimetres or so. These results were almost identical to the relative growth relationship between carapace width and claw length that Itō[5] demonstrated.

It is possible to divide these two groups statistically using the following discriminant formula:

$$Y = -16.5221 \ln CW + 14.5003 \ln CH + 33.8949$$

where *CW* is the carapace width in millimetres and *CH* is the chela height in millimetres. We can assign a given crab to the small-clawed group or the large-clawed group depending on whether the value for *Y* is less than or greater than -0.01123.

Of the total of 1,638 male crab specimens, 890 were in the small-clawed group and 748 were in the large-clawed group. We designated the small-clawed crabs "Group A" and the large-clawed crabs "Group B." And we kept these two groups separate when studying the results of our examination of the second maxilla.

**Moulting stage and terminal moult** By examining the tip of the second maxilla's basipodite, we were able to assign each specimen to one of four characteristic stages: the post-moult period, the inter-moult period or one of the two pre-moult periods.

The stages are as follows:

Stage A (the post-moult period - Figure 4-1): The margin of the basipodite is thin and very soft and appears white or milky. Crabs whose second maxilla are like this have very soft shells and have just moulted.

Stage B (the inter-moult period - Figure 4-2): The margin of the basipodite is thicker, hard, and dark brown in colour. No new basipodite epidermis or seta are forming inside the margin. Unlike Stage A, the shell in Stage B is hard.

Stage C (pre-moult period 1 - Figure 4-3): The thickness and colour of the basipodite margin are the same as in Stage B, but new basipodite epidermis and seta are forming inside the margin (arrows in Figure 4-3). However, the gap between the old basipodite epidermis and the new one is small, and they have not fully separated. The shell is hard, as in Stage B.

Stage D (pre-moult period 2 - Figure 4-4): The new basipodite epidermis and seta forming within the old basipodite have fully separated from the old basipodite epidermis and seta (arrows in Figure 4-4). Specimens with second maxilla like this are in what Itō[5] called the "double-skinned" stage, which immediately precedes moulting.

Our method of distinguishing the moulting stages according to the appearance of the second maxilla is basically that devised by

Moriyasu and Mallet[7]. In their report[7], the pre-moult period was divided into a total of six stages ($D_0$ to $D_4$), but because it was difficult to make these distinctions in practice, we settled on two (Stages C and D). For the sake of convenience, our Stage D comprises the period when the new basipodite's epidermis and seta have completely separated from those of the old basipodite as explained above. This is believed to be the period that immediately precedes moulting, and corresponds to Stages $D_3$ and $D_4$ in Moriyasu and Mallet's system[7]. We merged the other four stages ($D_0$ to $D_1$)[7] into our Stage C.

Figure 5 shows the percentage of specimens in each moulting stage for each month from August 1989 to October 1990 for the above-mentioned Group B (which had carapace widths of between 70 and 150 millimetres) and Group A (which had carapace widths of between 60 and 120 millimetres). For both groups, the general trend was for the percentage of specimens in the each moulting stage to be roughly the same for corresponding months of the two years in which the study took place.

In Group A (the small-clawed crabs), specimens were observed in Stage C (the moult preparation stage) beginning in May, when the percentage was 4.3 per cent. This figure then rose through stages to a peak in July-August (76.0 to 94.5 per cent). Specimens in Stage D were observed from August to October, reaching a peak of 20.0 per cent in September, to judge by the results of this study. Stage A was observed together with Stage D from August to October, with especially high figures in October (87.2 and 90.9 per cent).

Stage B was dominant from February to May, with figures ranging from 95.7 to 100 per cent.

Because these results show that so many of the small-clawed specimens, whose carapace widths ranged from approximately 60 millimetres up, were in Stage D (which immediately precedes moulting) in September and Stage A (which immediately follows moulting) in October, we concluded that moulting was taking place roughly in September and October. The moulting season that we postulated was almost identical to that reported previously[5]. And although we lacked data for the period from November to January, the fact that almost all the specimens we studied in Group A (94.5 to 100 per cent) were in either pre-moult Stage C or D or post-moult Stage A during the July-to-October period around which moulting is believed to take place, we concluded that the specimens in Group A moult once a year.

On the other hand, Stage A was observed in Group B (the large-clawed crabs) in September and October (9.1 to 63.3 per cent), while Stage B was the only stage during the other months. The fact that pre-moult Stages C and D were not observed at any time of the year among the large-clawed crabs means that no preparations were being made for moulting, and we therefore concluded that this group does not moult. In other words, the results of this study support the existence of the terminal moult that Conan and Comeau[4] noted among male crabs in the Gulf of St. Lawrence off the North Atlantic.

We also concluded that the specimens seen to have just moulted in September and October (the ones in Stage A) were former members of Group A that had just joined Group B upon moulting.

Teissier[8] noted that, when the male *Maja squinad* crab (a member of the spider crab family) matures, its claws become relatively larger than they were before maturing. A similar relationship between maturity and relative claw growth in male crabs has also been reported for the snow crab[4,9] and greater snow crab (*C. bairdi*)[10]. Generally, when the central nervous system of crustaceans secretes a sex hormone, in males the androgenic or male sex gland at the end of the vas deferens develops and secretes a male hormone, which causes the relative size of the claws to increase.[11] A similar process is thought responsible for secondary claw growth in male snow crabs as well, although it is not known what stimulates secretion of the sex hormone. We hope to work out a relationship between terminal moult and secondary growth upon maturation in subsequent research.

Figure 6 shows the distribution by carapace width of the specimens, divided into groups A and B using the discriminant formula mentioned earlier. As stated above, Group B was composed of specimens that had undergone terminal moult. Table 2 shows, for each size of crab, the percentage of specimens that had and had not undergone final moult. Although current regulations state that only snow crabs with carapace widths of 90 millimetres and up can be harvested, approximately 38 per cent of the specimens with carapaces between 80 and 89 millimetres wide (and therefore under

the legal harvesting size) have undergone terminal moult. Because the carapace width of these specimens will never increase, they will never grow to legal harvesting size. The minimum harvesting size hitherto in force is based on the assumption that male snow crabs continue moulting and growing until they die. However, it appears that there is in fact such a thing as a terminal moult, suggesting a growth pattern quite different from the one hitherto reported[1-3].

The results of this study also indicate that the carapace widths of male snow crabs which have undergone terminal moult range widely from approximately 70 to 150 millimetres, making it hard to believe that they are in the same instar. Although female crabs experience terminal moult immediately before their first spawning and are therefore assumed to undergo terminal moulting in the same instar,[12,13] we believe that male crabs differ from the females in that the instar in which they experience terminal moult varies from one crab to the next. The carapace width distribution graph in Figure 6 shows three modes at around 70, 90 and 115 millimetres. If we assume that each of these mode groupings corresponds to a single instar group, we can conclude that, since there are some in which several tenths of the specimens have undergone terminal moult, an instar group is made up of several age groups, not just one. Consequently, it will probably be necessary in any future consideration of ways to manage snow crab stocks to take into account the existence of terminal moult.

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## Literature cited

1. Osamu IMA, Seiichi[3] NIWA and Fumio YAMAGAWA, *Nippon Suisan Gakkaishi* (*Bulletin of the Japanese Society of Scientific Fisheries*) (1968), Vol. 34, pages 138-142.
2. M. Sinoda[4], *Nippon Suisan Gakkaishi* (*Bulletin of the Japanese Society of Scientific Fisheries*) (1968), Vol. 34, pages 185-190.
3. Katsuchiyo ITŌ, *Nissuikenkenpō* [Japan fisheries research society research reports] (1970), Vol. 22, pages 81-116.
4. G. Y. Conan and M. Comeau, *Can. J. Fish. Aquat. Sci.* (1986),

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[3] Translator's note: The characters with which the Japanese write their names can often be read several different ways. In this case, Masaichi and Masakazu are other possible readings. Transliterated Japanese names throughout this text reflect the commonest readings.

[4] Usually transliterated into English as Shinoda.

Vol. 43, pages 1710-1719.

5. Machiyo ITŌ, *Nissuikenkenpō* [Japan fisheries research society research reports] (1957), Vol. 3, pages 117-129.

6. A. Yamasaki, M. Sinoda and A. Kuwahara, *Proc. Int. Symp. King & Tanner crabs* (Alaska Sea Grant College Program: Anchorage, 1989), Report No. 90-04, pages 365-376.

7. M. Moriyasu and P. Mallet, *J. Crustacean Biology* (1986), Vol. 6, pages 709-718.

8. G. Teissier, *Trav. Stn. Roscoff* (1935), Vol. 13, pages 99-130.

9. J. Watson, *J. Fish. Res. Bd. Canada* (1970), Vol. 27, pages 1607-1616.

10. R. B. Brown and G. C. Powell, *J. Fish. Res. Bd. Canada* (1972), Vol. 29, pages 423-427.

11. Issō ŌZAWA, *Kōkakurui no Jikken* [Experiments involving crustaceans], (Kyōritsu Shuppan: Tokyo, 1984), pages 43-45.

12. Yutaka YOSHIDA, *Nippon Suisan Gakkaishi* (*Bulletin of the Japanese Society of Scientific Fisheries*) (1951), Vol. 16, pages 90-92.

13. Machiyo ITŌ and Toshio KOBAYASHI, *Nissuikenkenpō* [Japan fisheries research society research reports] (1967), Vol. 18, pages 127-128.

Table 1. Sampling data of male snow crabs

| Date | Fishing gear | Depth (m) | Numbers | Carapace width range (mm) |
|---|---|---|---|---|
| 24 AUG. 1989 | Trap | 273 | 55 | 66-142 |
| 19, 22 SEP. | Trap | 272 | 93 | 73-152 |
| 13 OCT. | Trap | 245 | 74 | 63-134 |
| 19, 22 FEB. 1990 | Danish seine | 245 | 149 | 67-120 |
| 5 MAR. | Danish seine | 235 | 97 | 88-115 |
| 24 MAY | Trap | 273 | 138 | 59-111 |
| 14, 19 JUN. | Trap | 272 | 255 | 68-152 |
| 25, 27 JUL. | Trap | 273 | 125 | 59-152 |
| 21, 31 AUG. | Trap | 243 | 41 | 63-140 |
| 10, 11, 24 SEP. | Danish seine<br>Beam trawl | 230-275 | 93 | 58-125 |
| 3, 4, 11, 15, 16 OCT. | Trap<br>Danish seine | 243-350 | 518 | 58-140 |

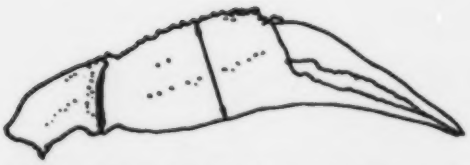

Fig. 1. Figure showing the measured part of chela height.

Fig. 2. Basipodite of 2nd maxilla of *C. opilio*. The part inside the square was used for determining molting stages.

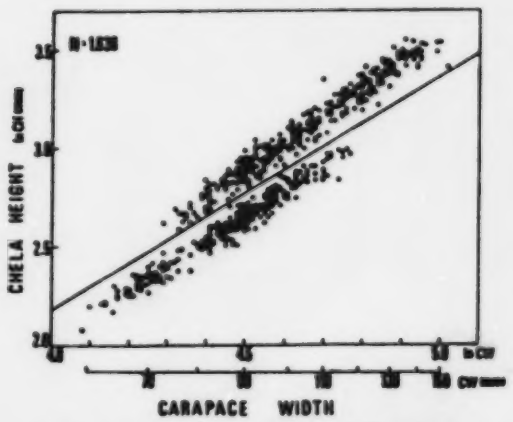


Fig. 3. Relationship between chela height and carapace width in the natural logarithm for the male snow crab. The line ($Y = -16.5221$ ln CW + 14.5003 lnCH + 33.8949) separates the two groups.

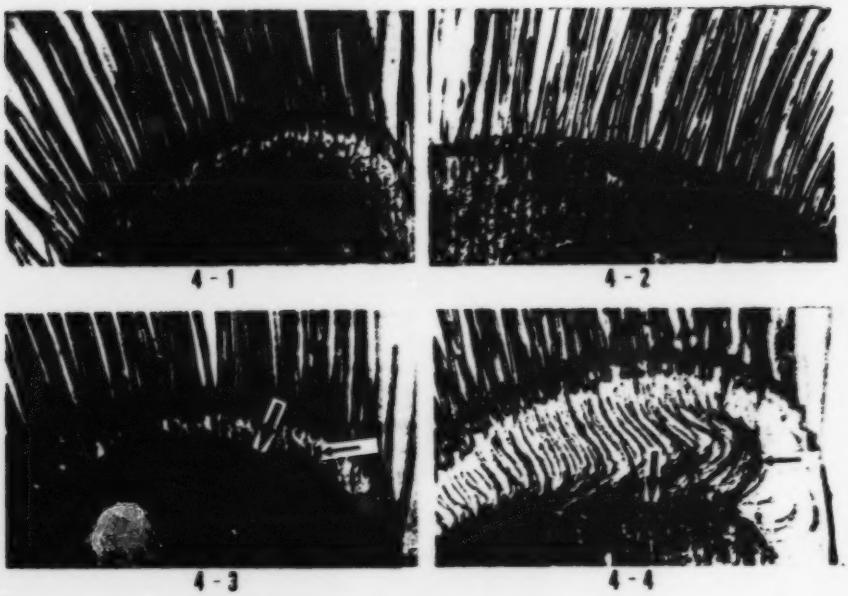


Fig. 4. Photographs of basipodite of 2nd maxilla showing molting stages.
1, A-stage (postmolt period)
2, B-stage (intermolt period)
3, C-stage (premolt period-1)
4, D-stage (premolt period-2)
Large and small arrows indicate the new epidermis and seta of the basipodite, respectively.

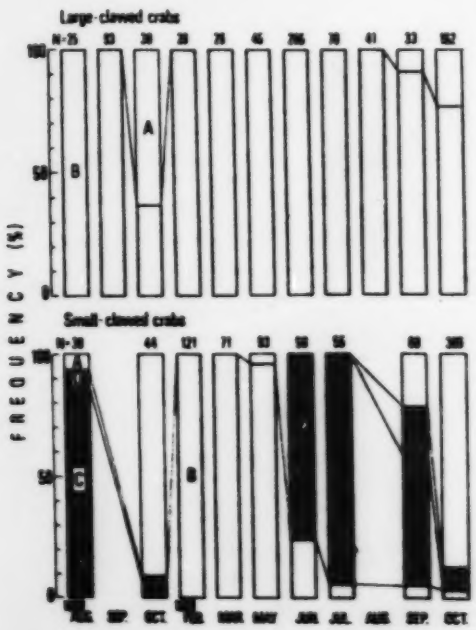


Fig. 5. Monthly percentage changes in composition of four molting stages in small-clawed and large-clawed crabs.
A, postmolt stage; B, intermolt stage; C, premolt stage-1; D, premolt stage-2.

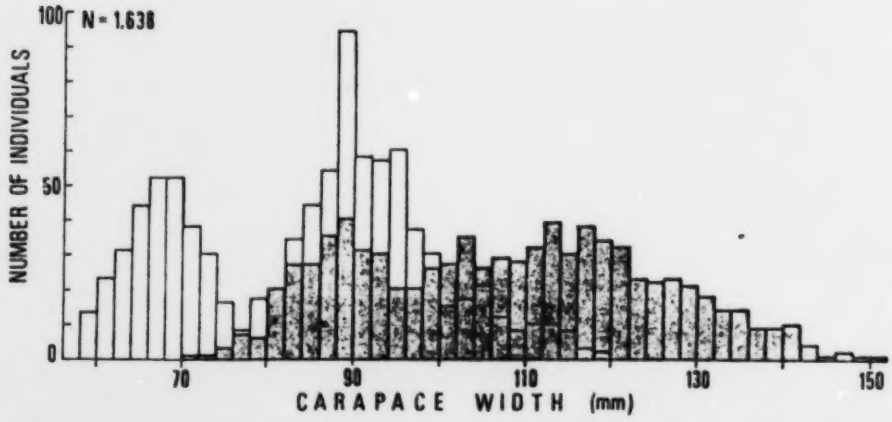


**Fig. 6.** Distribution of carapace width in male crabs, classified into the two groups by the dividing line in Fig. 3. White and black columns indicate small-clawed crabs and large-clawed crabs, respectively.

**Table 2.** Occurrence of large-clawed or small-clawed crabs in relation to carapace width

| Carapace width range (mm) | Large-clawed crab (%) | Small-clawed crab (%) |
|---|---|---|
| 60- 69 | 0 | 100.0 |
| 70- 79 | 14.2 | 85.8 |
| 80- 89 | 37.7 | 62.3 |
| 90- 99 | 34.4 | 65.6 |
| 100-109 | 66.5 | 33.5 |
| 110-119 | 84.0 | 16.0 |
| 120- | 100.0 | 0 |